Community Organization of Oribatid Mites in Various Forest Soils

by

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The community structure and feeding habits of oribatid mites were studied in different forest soils in Japan. The abundance of oribatid mites was larger in moder/mor soils than in mull soils. Community structure in terms of species richness did not differ among various soils, whereas diversity and evenness were higher in mull soils.

A litter bag experiment in contrasting soil types revealed a rigid relationship between habitat structure and the community structure of oribatid mites.

The effect of activity of the macrofauna on feeding an organic matter seems to influence the resource quality and quantity for oribatid mites and it was analyzed by a comparison of the composition of feeding habits of the oribatid mite community. Microphytophagous oribatid mites were dominant in mor soils, and their dominance decreased in the order of moder and mull soils. The decomposer macrofauna had a higher biomass in mull soils. Macrofaunal activity favored fragment feeders, while suppressed microphytophages.

The structure of oribatid mite community reflected the amount of habitat and the composition of their food, which were determined by the activity of soil macrofaunal decomposers.

Introduction

Oribatid mites are detritus feeders in soil ecosystems, and are a major group among the soil microarthropods in forest soils. Communities of oribatid mites in forest soils are known to be species rich and diverse [Wallwork 1983].

The community structure of oribatid mites has been studied using a litter bag method [Anderson 1975, Stanton 1979], and it seems to be related to the complexity of habitats in soils [Anderson 1978]. In many taxa of terrestrial ani-

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mals, habitat structure has been shown to define community structure [e.g. MacArthur and MacArthur 1961, Murdoch et al. 1972]. Anderson [1978] showed a positive relationship between habitat complexity and community diversity of oribatid mites in forest soils.

Habitat complexity is not a single factor defining community structure. Because soil-living microarthropods are less migratory, and they are living in or near the food resources, their food resources should be related closely to habitat structure. Therefore, the food and habitat for soil mircroarthropods are hardly separable. Anderson [1975] showed that because the body size was related to feeding habit and it may restrict utilization of soil micropore size, feeding habits of oribatid mites were related to their distribution in soil.

Petersen and Luxton [1982] reviewed the abundance and biomass of soil animal communities in various soils of the world. In deciduous forest soils in the temperate zone, they found striking differences in abundance and biomass between the mull and mor humus types: macrofauna being more abundant in mull soils, whereas microarthropods are more abundant in mor soils.

In most soil ecosystems, especially in mull soils, soil macrofaunal decomposers may have considerable effects on the amount and distribution of soil organic matter [Bal 1982]. Therefore, although predators in soil ecosystems may change the abundance and species composition of oribatid mites community, the activity of the macrofauna may also influence the microhabitat and food for oribatid mites.

In this study, a comparison of community structure of oribatid mites was made between mull and moder/mor soils in Japan, considering the resource amount and quality.

Study Sites and Method

Sampling Sites

Ashiu School Forest of Kyoto University

This forest is about 40 km north of Kyoto city, central Japan.

Ashiu-Bottom (AB) —— A natural broad-leaved forest with mull type soil in the bottom of slope.

Ashiu-Ridge (AR) —— A natural forest of *Fagus crenata* Blume with moder type soil on the ridge slope of Ashiu-Bottom.

Ashiu-Cryptomeria(AC) —— A natural mixed forest dominated by *Cryptomeria japonica* (D. Don) with mor type soil on the ridge of Ashiu-Ridge.

Ashiu-Picea (AP) —— A plantation of *Picea abies* Karsten with mor soil on the bottom of slope in the same region.

Sanbe School Forest of Shimane University

This forest is in the cerntral part of Shimane Prefecture, western Japan.

Sanbe-Broad leaved (SB) — A secondary deciduous broad-leaved forest dominated by *Quercus serrata* Murray with moder soil.

Sanbe-Cryptomeria (SC) — A *Cryptomeria japonica* plantation after clear cutting of the secondary forest with mull type soil.

Sampling Methods

Soil samples were collected using a cylindrical core sampler 25 cm^2 in surface area and 8 cm in depth. Fifteen to twenty soil samples were collected from each sampling site and the soil microarthropods were extracted, using a modified MacFadyen's extractor [Takeda 1979] over 5 days.

Details of the sampling sites and methods have also been reported elsewhere [Kaneko and Takeda 1984, Kaneko 1985, Kaneko et al. 1990].

Soil samples were collected once from AC, AP and SB, and twice from SC sites. In AB and AR, samples were collected sixteen times at monthly intervals during a study period of two years.

Study Using Litter Bags

The colonization process and change in community structure of oribatid mites in response to newly fallen leaves were studied, using a litter bag method. Litter bags were put into AB and AR sites on November 26, 1981. Newly fallen beech leaves were collected near to the study plots. Leaves were cut into discs of 3 cm diameter, using a cork borer, so as to contain a mid-rib of leaf. Twenty discs were put into a litter bag of 10 cm × 10 cm in area with mesh size of about 2 mm. The initial mean weights of the leaves per litter bag was about 1.7 g. From April 1982 to November 1983, bags were recovered eleven times. The soil microarthropods in the litter bags were extracted, using a Tullgren extractor.

Analysis of Community Structure

The community structure of oribatid mites was analyzed, using abundances of adult oribatids. The diversity of the communities was expressed by the Shannon-Wiener information function (H') and the evenness of the communities was calculated by the Pielou's J' index [Pielou 1966]. The feeding habits of oribatid mites were classified into sub-groups according to Kaneko [1988].

Results and Discussions

Abundance and Community Structure of Oribatid Mites

Abundance and community structure of oribatid mites in the sampling sites are shown in Table 1. Although the oribatid mite communities may show

Table 1. Abundances and community structures of oribatid mites in various forest soils in Japan.

Soil type Study site	Abundance (per m^2)	Number of species	Diversity (H')	Evenness (J')
Mull				
Ashiu-Bottom*	28,400	50.5	4.457	0.784
Sanbe-Cryptomeria**	39,800	47.5	4.265	0.759
Moder				
Ashiu-Ridge*	54,800	56.6	4.043	0.697
Sanbe-Broadleave	80,400	67	4.193	0.691
Mor				
Ashiu-Cryptomeria	84,500	53	4.039	0.705
Ashiu-Picea	51,060	38	3.753	0.715

* mean value of 16 times sampling

** mean value of 2 times sampling

seasonal change in abundance, magnitude of the fluctuation expressed by the ratio of maximum to minimum was 1.97 in AB, and 2.09 in AR. Seasonal changes in abundance of oribatid mites in the forest soils were relatively stable [Kaneko 1985]. The abundance of oribatid mites in the study sites ranged from 28,500 to 86,500 m^{-2}. Abundances were higher in the mor or moder soils and lower in the mull soils. These results are comparable to those in the review by Petersen and Luxton [1982].

Species richness ranged from 38 to 67. Except the AP site, the number of species was not different among the study soils. Diversity was influenced more by evenness. Divesity H' and evenness J' were higher in the mull soils than in moder/mor soils.

Takeda [1987] showed that, within a habitat, the diversity of the collem-

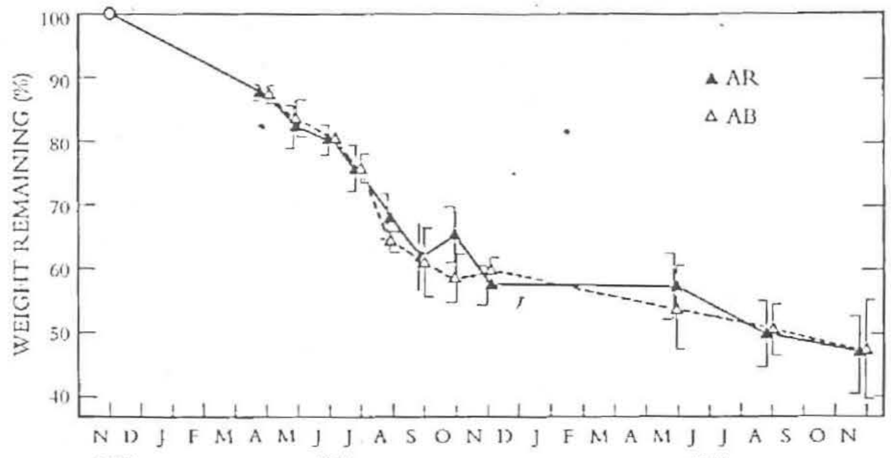

Figure 1. Changes in ratio of weight remaining of beech leaf litters in fine meshed bag placed on two contrasting temperate deciduous forest soils in Ashiu, Japan.

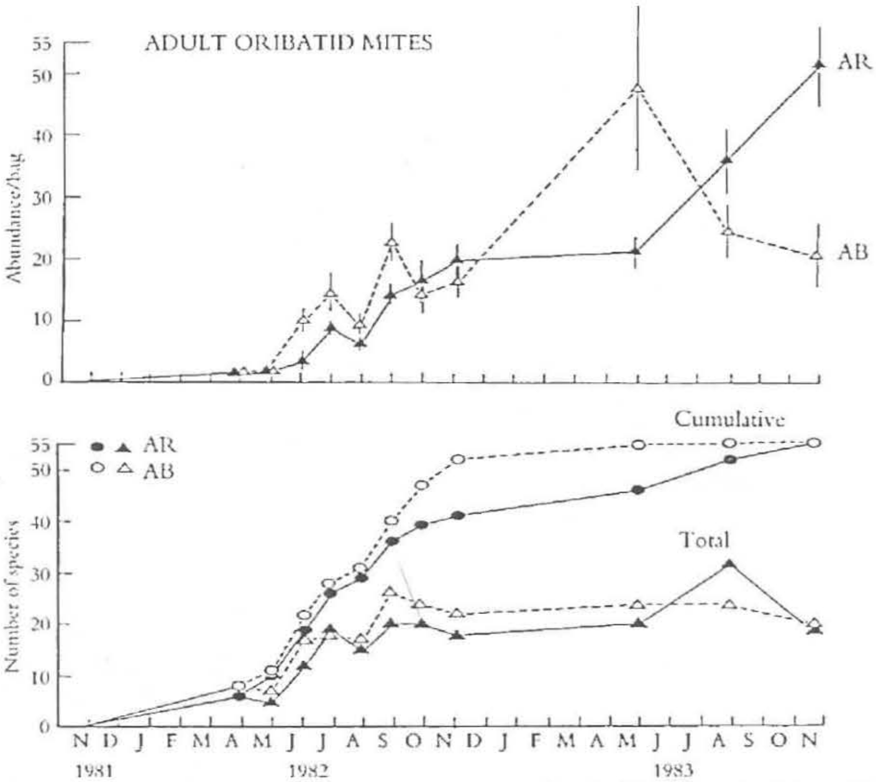

Figure 2. Changes in abundance and species numbers of oribatid mites colonizing of beech litter bags in two contrasting temperate deciduous forest soils in Ashiu, Japan.

bolan community in a pine forest was correlated positively with the amount of organic matter in a mor soil. Detailed measurement of amounts of resources is difficult in forest soils, although accumulation of organic matter on the soil surface is larger in moder/mor soils than in mull soils. Thus the abundance of oribatid mites may be correlated positively with the amounts of organic matter between habitat, but the community diversity of oribatid mites may not be simply related to the amount of organic matter.

Colonization of Litter Bags by Oribatid Mites

In the AB and AR sites, the colonization of litter bags by oribatid mites was studied. The changes in the decomposition rates of leaf litter are shown in Figure 1. Although the soil humus types were different in these sites, the decomposition processes were similar in both sites.

The abundance and the species number of oribatid mites colonizing litter bags are shown in Figure 2. A few adult oribatid mites were found in April and May 1982, whereas the number of mites increased from July 1982 on both the sites. Although some decreases in abundance were observed in August 1982, a number of mites increased continuously until November 1983 in AR site. In AB site, some decreases were observed in August and October 1982. After reaching their maximum abundance in May 1983, their abundance decreased until November 1983. Significant difference in abundances in each sites occurred only in September and in November 1983 (t-test). Colonization process in abundances was, therefore, similar in both the sites.

Changes in the total number of species found in the litter bags were similar in both the sites in the first year as was the abundance of adult oribatid mites. In the second year, the number of species remained in the same level as in the autumn of the first year in AB, whereas in AR it increased in August 1983 and then decreased. The species number of oribatid mites per litter bag is not shown in Figure 2, although, changes in mean number of species increased continuously until September 1982 in both the sites, except in August 1982. In August 1983, more than 10 species were found in the bags and then the number of species decreased in November 1983. On every sampling occasion, there was no significant difference in the number of species between in both the sites (t-test). The cumulative number of species increased continuously in the first year in both the sites. In AB site, no additional species appeared after May 1983, although in AR site some increase was observed in the second year. In November 1983, the cumulative number of species colonizing the litter bags was 55 species in both the sites. The totals of 101 and 100 species of oribatid mites were collected from AB and AR sites, respectively, during the two-year study [Kaneko 1987]. More than half of the species colonized, therefore, the litter bags in the two years period from the beginning of decomposition.

The community structure of the colonizing sub-community of oribatid mites is shown in Figure 3. The diversity of colonizing oribatid mites was low in April and May 1982, although the index values were more than three, except in November 1982 and November 1983 in AR site. Evenness indices were near unity at the beginning of colonization and then showed a continuous decrease in both the sites. The ratio of the total species to the mean number of species per litter bag were higher at the beginning of the study and then decreased. This indicates a convergence of species composition in the sub-communities in the litter bags with the progress of decomposition. The oribatid mite communities in the litter bags consisted of small number of species and number of individuals were not different among the species at the beginning of colonization, and then the communities changed into the structure of many species but dominated by small number of species.

Between AB and AR sites, the abundance and species composition of oribatid mite community was different and the physical property of the mineral soil was also different [Kaneko 1985, 1987], although the colonization process in the term of community structure in the litter bags was quite similar among the bags. Leaf litter in the bags should have changed quantitatively and qualitatively [Anderson 1973a, 1973b]. It is very difficult to measure habitat complexity for

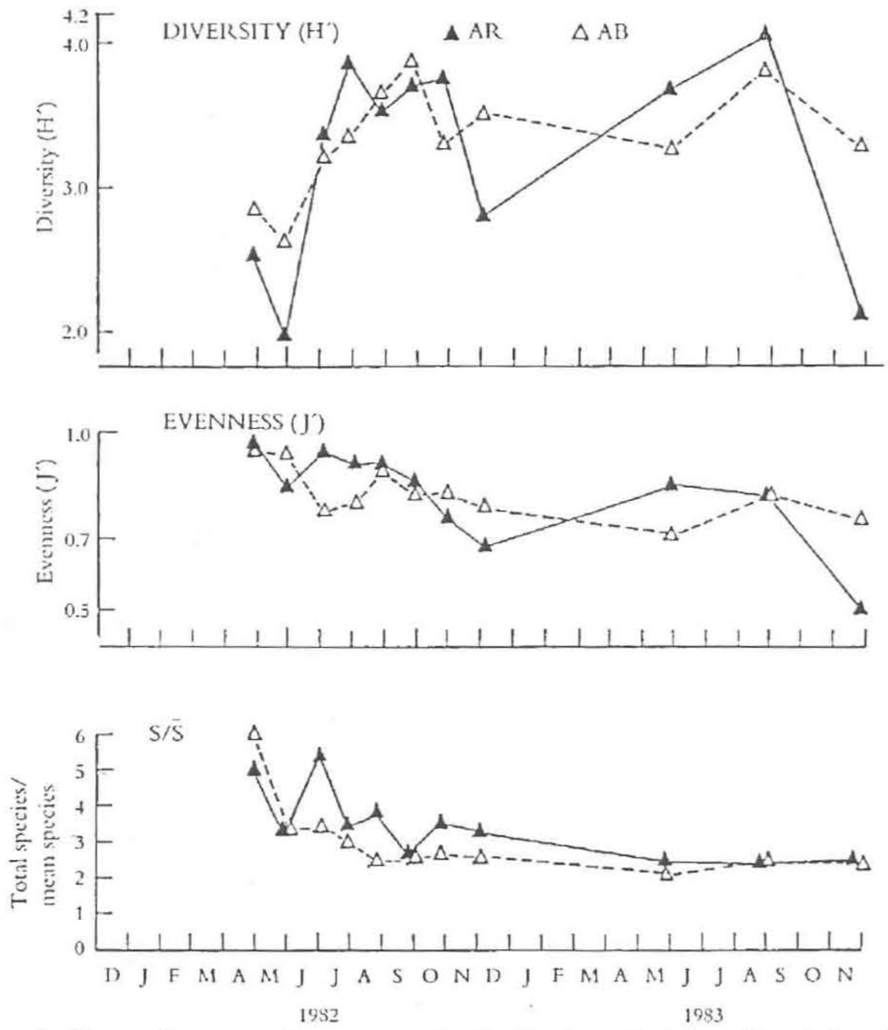

Figure 3. Changes in community structure of oribatid mites colonizing of beech litter bags in two contrasting temperate deciduous forest soils in Ashiu, Japan.

oribatid mites in a soil environment with an appropriate scale [Anderson 1978]. While the soil structure in both the sites was quite different, the decomposition rate and process was similar. This may be because of the use of the litter bags of fine mesh which inhibited a colonization by macrofaunal decomposers into the litter bags. Thus, the litter bags used in this study provided a similar habitat structure for oribatid mites living in different soil types.

Anderson [1975] showed a similar colonization process for oribatid mites in beech and chestnut litter bags. Stanton [1979] found that in a standardized litter, the diversity and species richness was similar in both temperate and tropical oribatid mite communities. Therefore, these studies and present study suggest that similar community structures of oribatid mites seem to be established under similar structures of habitat.

Feeding Habit of Oribatid Mites

Kaneko [1989] classified the feeding habits of oribatid mites according to the shape of their mouth parts and analysis of gut contents. Macrophytophages directly feed on dead organic matter, and their chelicerae are larger and more vigorous, whereas microphytophages feeding on fungal hyphae and/or bacteria have smaller and more delicate chelicerae. Fragment feeders feed on fine particulated matter which seemed to have been broken down beforehand by other soil animals. Panphytophages feed on dead organic matter as well as on microbial tissues. These four types were separated numerically by the cheliceral shape.

Seasonal change in the relative abundance of oribatid mites with different feeding habits is shown in Figure 4. In AB and AR sites, the composition of feeding habits was stable and showed no seasonal change.

Panphytophages could not be distinguished from macrophytophages without analysis of the gut contents, because in different soils they may change their

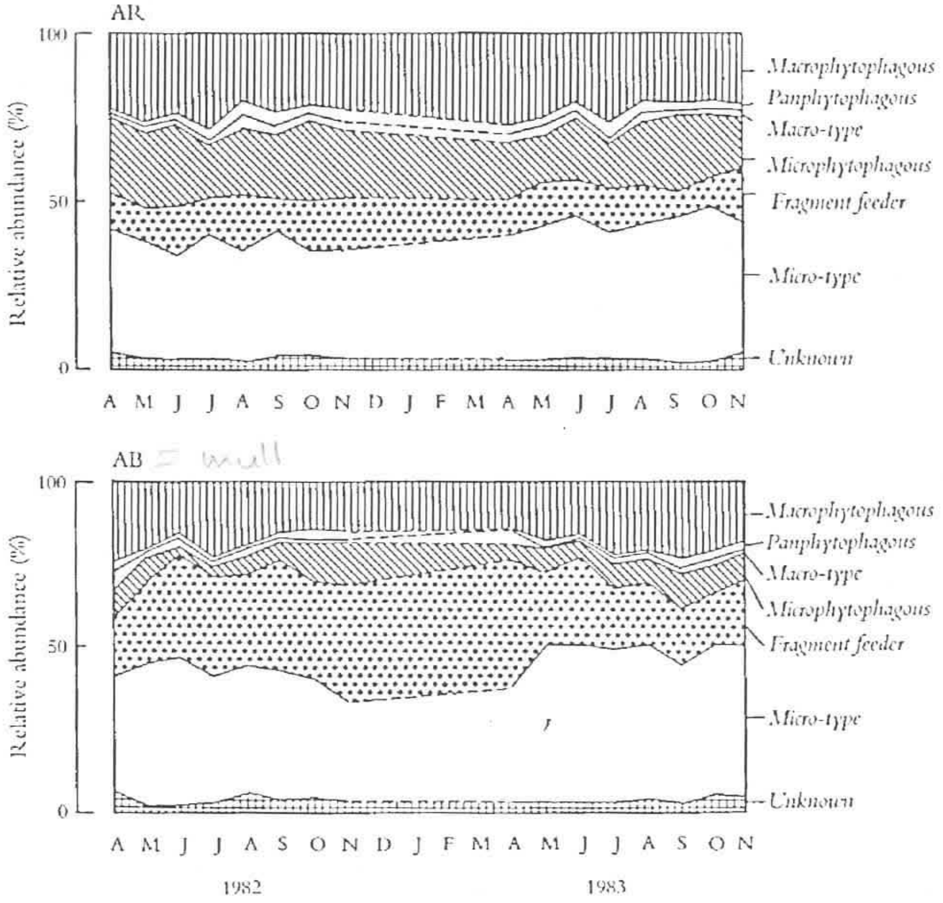

Figure 4. Seasonal changes in relative abundances of each feeding habit in oribatid mite communities in Ashiu, Japan.

habits, whereas fragment feeders are not able to change their feeding habits [Kaneko 1989]. Precise analysis of gut contents in each study soil is, therefore, necessary. In the present study, macrophytophages and panphytophages were not separated., and adult oribatid mites were classified into microphytophage-type, macrophytophage-type, and fragment feeder-type.

The relative abundance of feeding types of oribatid mites in all the study sites is shown in Figure 5. The microphytophage-type was dominant in every site. The relative abundance of microphytophages was especially high in mor soils in AC and AP, but it was lowest in mull soils of AB and SC. Fragment feeders were abundant in AB and SB, and were scarce in AC and AP.

Fragment feeders are believed to feed on the faeces of macrofauna or physically broken down particles. The relative abundance of fragment feeders may express the activity of macrofauna in the soil and/or the quality of litter. The biomass of decomposer macrofauna in AB and AR sites was reported to be 3.0 and 9.6 g dry weight·m^{-2}, respectively [Takeda and Kaneko 1988]. On the other hand, decomposer macrofaunal biomass was 0.65 and 2.65 g dry weight·m^{-2} in the natural broad-leaved forest at the site SB, and the *Cryptomeria* plantation SC [Kaneko unpubl.], respectively. The biomass of the decomposer macrofauna was more abundant in mull soils. There was no data on the biomass of macrofauna in AC and AP sites, but Watanabe [1972] showed a small biomass of macrofauna in a natural *Cryptomeria* forest on the ridge in Ashiu. Petersen and Luxton [1982] also showed that in temperate conifer forest soils the macrofauna tended to have a smaller biomass than in a temperate broad-leaved forest soils. Fragment feeders were abundant in AB and SB sites, very few in AC and AP sites. In SC site, where mull soil was found, fragment feeders were much more abundant than in AR, although it was lower than in SB. Thus, fragment feeders may be scarce in the coniferous forest soils.

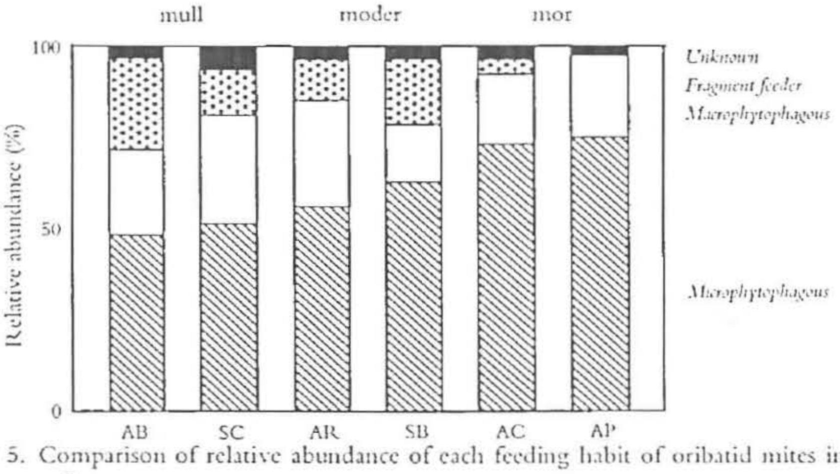

Figure 5. Comparison of relative abundance of each feeding habit of oribatid mites in various forest soils.

Effect of Activity of Macrofauna to Oribatid Mite Community

According to the feeding habit analysis, the activity of the soil macrofauna and litter type seem to be important for the organization of the oribatid mite community. Petersen and Luxton [1982] showed that in a mull soil the macrofauna are more abundant, whereas in a moder or mull soil and in coniferous forest soils, the macrofauna populations tend to be fewer. The abundance of microarthropods was shown to have adverse pattern to that of macrofauna, e.g. microfauna was more abundant in mor/moder and coniferous forest soils than mull soils. Bal [1982] emphasized the relationship between soil humus accumulation and the activity of soil fauna.

The relationship between abundance of oribatid mites and biomass of decomposer macrofauna in the study soil is shown in Figure 6. When the decomposer macrofauna is feeding on soil organic matter, abundance of microarthropods may be suppressed by a decrease in food resources and living space. This is shown also by the litter bag experiment in AB and AR sites. Providing litter resources well protected against macrofaunal feeding by fine mesh, a similar subcommunities were established by colonization of oribatid mites living in different soils, where a different community structure has been developed. Composition of feeding habits of oribatid mites differed in different soils. Active feeding by the macrofauna in a mull soil seems to reduce the abundance of oribatid mites, especially that of microphytophages, and fragment feeders may increase using comminuted particles and faecal matters produced by soil macrofauna.

The effect of a change in feeding habits on community structure is shown in Figure 7. Because the change in the number of species is small, a decrease in dominance of microphytophagous oribatid mites can lead to an increase in diversity of the community. There was a significant negative relationship between

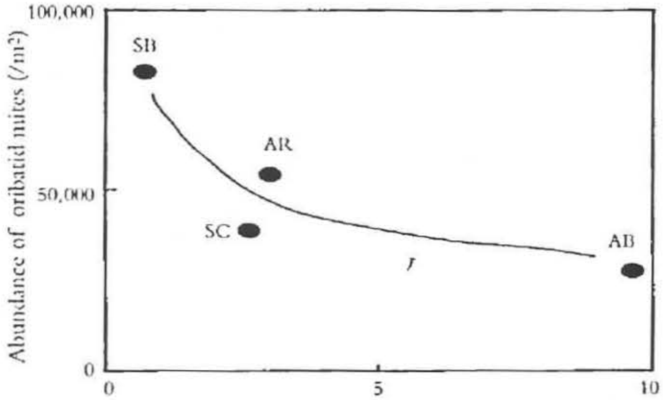

Figure 6. Relationship between biomass of soil macrofaunal decomposers and abundance of oribatid mites in the study forest soils.

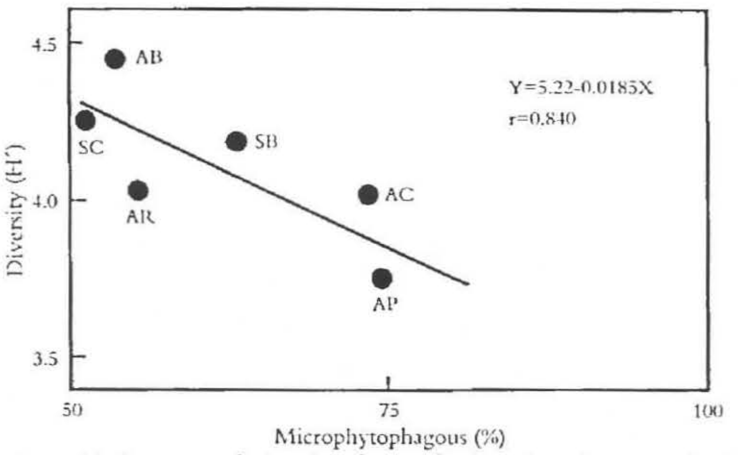

Figure 7. Relationship between relative abundance of microphytophagous oribatid mites and diversity of community.

the relative abundance of microphytophagous oribatid mites and the diversity of the community ($P < 0.05$).

In this study, the biomass of microorganisms, as food for oribatid mites was not estimated. A decrease in relative abundance of microphytophages may be influenced by the change in biomass and species composition of microorganisms, this in turn seems to be related to the activity of macrofaunal decomposers.

Organization of Oribatid Mite Communities in Forest Soil Ecosystems

In this study, I compared oribatid mite communites among forest soils with different soil humus types. Takeda [1987] showed stability and predictability of a collembolan community in a mor soil of a pine forest. The collembolan community was composed of a few dominant species and showed positive relationship between litter accumulation and diversity as well as species richness. Numerical structure of the collembolan community was similar to that of oribatid mites in mor soil type.

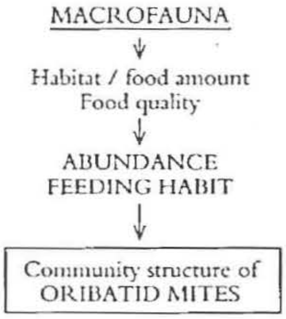

Figure 8. Effect of macrofaunal activity on the community structure of oribatid mites.

In soil ecosystems, interactions among soil organisms including predation, and resource competition seem to influence the community structure of soil organisms. Soil macrofaunal decomposers have considerable effects on the decomposition of soil organic matter by their feeding activities [Figure 8]. The oribatid mite communities are organized by the structure of habitat and the abundance of food resources, and there is a change in feeding habit composition. In a mull soil where conditions for the macrofauna are favorable, oribatid mites can be suppressed by macrofaunal activity which reduces habitat availablity and food resources for oribatid mites. In mor/moder soils the habitat and food are more abundant than in mull soils. Fragment feeders may be able to increase using faeces and physically broken organic matter made by the macrofauna in mull soils. The abundance and composition of oribatid mites in mull soils are determined mainly by the activity of soil macrofauna.

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